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To William Francis Esq Ph. D. F.L.
&c &c
With the Compliments
of the Author
Dec 23 1844

WHAT SCIENCE CAN DO
FOR
THE IRISH FARMER:

BEING AN INTRODUCTORY LECTURE ON

AGRICULTURAL CHEMISTRY,

DELIVERED BEFORE

THE MEMBERS OF THE SEAFORDE AND HOLLYMOUNT
FARMING SOCIETY;

WITH

COPIOUS EXPLANATORY NOTES,

AND

ANALYSES OF SOILS, MANURES, &c.

BY JOHN F. HODGES, M.D.

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the Pharmaceutic Association of North Germany, and
Licentiate of the Apothecaries' Hall of
Ireland, &c. &c.*

DUBLIN: WM. CURRY, JUN. & Co. DOWNPATRICK: C. PILSON.
BELFAST: H. GREER.

1844

HISTORICAL
MEDICAL

Downpatrick Co Down
Dec 23d. 1844

Dear Sir

I send you a copy of a lecture on agricultural Chemistry delivered by me before an association of Farmers in this county and published at their request. In this country the importance of the inorganic constituents of plants is not yet sufficiently admitted and I have endeavoured to popularise the views of our German friends so as to render them intelligible to the Irish Farmer. I will feel much obliged by your giving a notice of the pamphlet in an early number of the Chemical Gazette s I am anxious that I should receive your valuable support

in combatting the advocates of the
Humus theory which is generally entertai
by agricultural writers in this country

I send a post office order for the
renewal of my subscription to the Gaze
I hope you continue to find an extens
support; in this remote district I derive
great pleasure and advantage from its
perusal. Do you exchange the Gaze
with Wackenroder's Archiv der Pharma
A short time ago I had a letter from Jen
in which he expressed a wish to negotiat
its exchange with some of our scientific Jour

Believe me Dear Sir
Yours faithfully
John F. Hodges

Dr Wm Francis
Editor of the Chemical
Gazette &c &c

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William Francis Esq Ph.D.

&c &c

London —

AGRICULTURAL CHEMISTRY.

INTRODUCTORY LECTURE.

Gentlemen,

I have been requested to come here for the purpose of delivering some observations to you on what is termed Agricultural Chemistry. It is unnecessary to apologise to the members of a Farming Society for bringing this subject before them, or to occupy your time with many remarks upon the great importance of agriculture to this country, and the beneficial results which must be derived from the diffusion of any knowledge by which the labours of the farmer would be facilitated, the soil of the country improved, disappointments in a great measure prevented, and the produce of our fields increased. The census of the population of Ireland taken in 1841, shows us that two-thirds, or 66.1 out of every one hundred individuals in the kingdom depend for their subsistence upon agriculture.* A science, therefore, which has for its object the study of the means by which the 20 millions of statute acres which Ireland contains† may be made to double or treble their produce, has strong claims upon the attention of both landlord and tenant, and deserves

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* From the census of 1841, it appears that in Ireland there were employed

In agriculture, ...	5,406,743	or 66.1 per cent.
In trade and manufactures,	1,953,688	24.0
Otherwise, ...	813,535	9.9
	8,173,966	100.0

† The area of Ireland, according to the Ordnance Survey, is 20,808,271 statute acres, of which there are 6,295,735 uncultivated.

the serious and careful consideration of every one who feels an interest in the happiness and advancement of his country. I will therefore make use of this opportunity which has brought us all together to offer you a few remarks upon this most interesting and important subject. I should mention to you that 1 do not profess to have any practical acquaintance with the mechanical operations of agriculture; but I have had my thoughts and observations for some time diligently directed to its connexion with chemistry; and I am confident that in attempting to show you something of what that science has already done, and is yet able to accomplish for the farmers, I shall be able to convince you that it is your advantage, that it is your duty to make yourselves acquainted with its principles.

I will require in the course of my observations to employ a few technical terms, which may at first appear difficult to some of you, but the difficulty is only imaginary, and will soon vanish. Every trade and profession, even that of the husbandman has its technical terms, which appear very hard looking to those who hear them for the first time; but these terms do away with the trouble of long descriptions, and, when once acquired, greatly facilitate our progress.

Never was there a more urgent necessity, than exists in this country at the present time, that some great effort should be made by all classes to advance its too much neglected agriculture. In consequence of the changes which have taken place in the laws regulating the importation of grain, and the rapid increase in our population, it becomes absolutely necessary, that to compete with the foreign corn grower—to prevent our landowners becoming bankrupts and our farmers beggars—we should adopt some means of increasing the produce of our fields. In Agricultural Chemistry we are offered the only rational means for this purpose; and fortunately the state of the public mind at the present time, seems peculiarly favourable to the welcome reception of its principles. Old prejudices have been broken through, and farmers who, as a body, were proverbially unwilling to adopt new opinions, or practices, different from their forefathers, are now generally anxious to embrace any plans which offer a probability of bettering their condition. Enjoying the blessings of peace for the last thirty years, the attention of Europe has been steadily directed to the cultivation of science, and you are all aware that the most brilliant success has attended the application of its principles to the useful arts. But, strange to say, that in these countries the application of science to agriculture—the most important branch of national industry—has, until very lately, been totally neglected.—Hitherto, the assistance of chemistry—that most useful of the sciences—has been confined to our manufactures. And what has it not done for them? It has introduced improvements into almost every department, and has even created new and hitherto unthought of branches of trade, giving employment to large communities and wealth to thousands. It has, in fact, become the very foundation of the manufacturing greatness of England. It can do as much, and more, for agriculture. The attention of some of the most eminent philosophers of the age is now, however, directed to Agricultural Chemistry. In Germany, Liebig, whose honoured name is familiar as a household word in this country, and in France, Boussingault, by their laborious researches and valuable experiments, have forced the most sceptical to confess that the philosophy of the Laboratory is capable of being carried out into the operations of the Farm. It is a well-known fact, that the celebrated French chemist, Lavoisier, even at a time when science was far from having attained its present state, by its application, doubled the produce of his fields, and at the same time quintupled the number of his flocks. Let not, then, the farmer be faint-hearted.—Blame not high rents as much as yourselves, if, neglecting the assistance which science offers, you remain poor.* I do not ask you to believe what cannot be proved, when I tell you, that the produce of this country might be easily doubled. I have no doubt but that it will yet be increased four-fold.†

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* Since the delivery of the opinion expressed above, I have conversed with some farmers who were present. They seemed to have an apprehension, that by such representations of the improveable condition of the soil of the country, landlords would be induced to entertain ideas of its value, injurious to the interests of the occupier. To those who entertain such foolish fears respecting the progress of the improvement, I would advise the study of Lord Stanley's admirable speech at the meeting of the Liverpool Agricultural Association.

† Mr. Blacker, of Armagh, who has devoted more attention to this subject than perhaps any person in Ireland, assures us that he can shew farms of average land in Armagh, which, by improved culture, have, in his own time, been made to give produce *treble* to what they formerly yielded.

According to the Ordnance Survey, the area of the County of Down, exclusive of towns, is 610,284 statute acres; out of which, there are 514,180 acres of arable soil, possessing as many advantages as are enjoyed by any land in the world. We have every description of surface—the gentle undulating hillock, the valley, and the lofty mountain—all combining to give beauty and value to its soil. We have in the south the granite rocks of Mourne, rich in potash, flint, and other substances, which I will hereafter shew you are essential to the growth of your crops of wheat and grass, while in the north we find inexhaustible mines of limestone, and almost every where valuable beds of marl. There is, in fact, no county in Ireland which presents greater advantages of soil and situation, or in which there are more reasonable grounds, judging from past experience, to conclude, that the introduction of an enlightened scientific system of agriculture would contribute more to increase the happiness and prosperity of its moral and industrious inhabitants. If I were desirous of producing an impression, upon the mind of a stranger, respecting the progress of improvement in this part of Ireland, I would tell him, how two or three hundred years ago, your hills were covered with wild jungles and thick natural forests, your valleys swamps, scarcely passable, and inhabited by a race of people almost as uncultivated as the fields themselves.* I would tell him that the condition of this country, at that time, was such, that access to it from other parts was almost impossible, and that unfortunate travellers who had occasion to visit it, experienced so much suffering, in hobbling through its narrow and broken causeways, that a large district received the Irish name of *Magheradroll*—viz., the field of difficulties. And turning over the ancient records of the county, I would shew him how Loughinisland, and other parts of this Barony, were considered chiefly valuable as places where charcoal could be made to burn in the fires of the then proprietor of the chief property in Lecale, the Lord Cromwell! Such was the barbarous state of things at that period, in this country, that

> "People thrashed their corn with fiery flail,
> And ploughed with horses harnessed by the tail."

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[*] The Barony of Kinalarty, in 1841, contained 40,323 statute acres, and 20,895 inhabitants.

But, since then, civilization has spread over the land ; and the introduction of new methods of culture, the invention of improved ploughs, the drainage of the soil, and the application of lime and marl, have brought about a complete change in the appearance of the landscape. The fields where your forefathers would have considered it madness to sow their corn, were they not, in the past harvest, covered with a rich and glorious crop, making glad the hearts of their more industrious and better instructed children ? Let the farmers of Kinalarty remember how much has been done within the last few years in their own neighbourhood, by the agency of Agricultural Societies, and the assistance of kind and liberal-minded landlords.* But, as I have said before, the times require that unusual efforts should be made by the farmer, to obtain from the soil the largest amount of produce which it is capable of yielding. The efforts hitherto made in this country have been chiefly devoted to its mechanical improvement. Some enterprising farmers have, indeed, at various times, deviated from the beaten track ; but, as their labours were conducted without any correct knowledge, of either the constituents of the soil, or of the substances required for the growth of plants, their experiments were necessarily most unsuccessful, and their sacrifice of labour and capital was held up by the old practical change-hating farmer as a beacon to deter others from imitating their example. In particular, immense sums of money have been thrown away, by loading the exhausted soil with manures with the properties of which they had not the slightest acquaintance. Such indeed was the case in all countries until within the last few years ; but was especially ruinous and destructive in a poor country like Ireland. In other countries Agricultural Chemistry has altered this state of things. It has shewn what the land can be made to produce, and has taught the farmer what the experience of thousands of years could not teach him—the true causes of the impaired fertility of his fields, and the nature of the treatment which they require to yield him abundant harvests. It has enabled him, as Professor Liebig remarked the other day at the dinner to which he was invited by the grateful agriculturists of Scotland, to found his calculations "upon the real and not the imaginary value of manures." Surely it is not too much to expect, that what industry, directed by this science, has accomplished in Flanders, in England, and in Scotland, might also be successfully performed in Ireland.

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* The supply of sound seed, and of the new manures, at a reduced rate to their tenantry, by the land proprietors of this county, has been productive of the most beneficial results. We find this strikingly evidenced by the decrease in the number of civil bill processes, the great improvement in the dwellings, dress, and general comfort of the small farmers. All now is content and cheerfulness, where, a few years ago, we had despair and misery.

I shall now, Gentlemen, endeavour to give you an outline of some of the leading principles of this most important science; and, as I shall make use of the most simple and familiar language, I trust that my observations shall be easily understood and remembered by every person present. To assist your memory, and facilitate reference, I shall arrange my remarks under three heads. I shall consider

I. THE FOOD WHICH OUR CROPS REQUIRE FOR THEIR SUPPORT.
II. THE ORIGIN AND COMPOSITION OF WHAT I SHALL TERM NATURAL SOILS.
III. THE NATURE AND USE OF ARTIFICIAL SOILS OR MANURES.

First, then, of the food or materials which our crops require for their support.

It will be evident to you, that a knowledge of the food which plants require for their growth, and of the essential conditions upon which their life and perfection depend, must be regarded as of the greatest importance to the practical farmer. Agricultural Chemistry teaches us, that, for the support of the life of plants—for the growth of the stalk—for the formation and perfect development of the seed—*sixteen* substances are required; and that of these the plant can procure only *four* from the air which surrounds it, and the water it drinks in from the clouds; the remaining *twelve* substances must be procured from the soil on which it grows, or be supplied by the agency of man when the soil does not contain them.

It was formerly erroneously supposed that the atmosphere, as that immense ocean of air which surrounds the globe is termed, was a simple element;[*] but it is now well known that it is most complex in its composition, being a mixture of certain *airs* or *gases*, known among chemists by the names of OXYGEN, NITROGEN, and CARBONIC ACID, and containing, diffused through it at all times, a small but essential quantity of AMMONIA,[†] and a variable proportion of WATERY VAPOUR. The three substances last mentioned, carbonic acid, ammonia, and water, are compound bodies. Carbonic Acid being formed by the union of oxygen gas with a black solid inflammable substance, having the appearance of charcoal, called CARBON; ammonia being a compound of two gases, nitrogen and hydrogen; and water being composed of the latter and oxygen. It is by the decomposition of these compound bodies that the growing plant receives those elements which are supplied to it from the atmosphere, and which may be regarded as the essential constituents of its food. To those who have seen a bulbous plant, the hyacinth, for example, thriving vigorously in a glass of water, I need not say that the presence of the soil is not a necessary condition of vegetable life; but to all those plants which are the subjects of your anxious care, the presence of the substances contained in it is absolutely indispensable. During the life of a plant, the carbonic acid which is taken into its circulation undergoes decomposition, its oxygen is given off from the leaves, while its carbon remains behind, and becomes a part of its structure; and, by certain processes, we are able to discover that it forms nearly 50 per cent. of all our cultivated plants.[‡] Ammonia

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[*] By the term *element*, chemists understand a simple substance from which no other kind of matter can be procured; thus iron is an element, as we can procure from it nothing but iron, while sulphate of iron (the substance commonly termed green vitriol) is regarded as a *compound* body, as we are able, by chemical processes, to procure from it two kinds of matter, sulphuric acid and iron.

[†] Ammonia is a kind of air which, when mixed with water, forms the liquid sold under the name of hartshorn. It produces the peculiar pungent smell which we perceive in stale urine, in hot stables, and in the neighbourhood of badly kept manure heaps.

[‡] 100 parts of the following substances, when all their moisture has been expelled by drying, contain—

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.
Wheat (*the grain*)	46.1	5.8	43.4	2.3
Oats *do.*	50.7	6.4	36.7	2.2
Potatoes,	44.0	5.8	44.7	1.5

The quantity of dry material contained in 100 parts of those substances is, in Wheat, 85.5; Oats, 79.2; Potatoes, 24.1.

and water also undergo decomposition when absorbed by plants—the former yielding to them its nitrogen, the presence of which is necessary to the formation of some of the most valuable ingredients of our crops; and, as I shall presently have occasion to show you, indispensable for the support and nutrition of animals using them as food; and the latter supplying them with hydrogen, which is essential to the production of their starch and oil.

If you take some pieces of straw, or a few grains of wheat, and hold them on a piece of metal, a tea-spoon, for example, over the flame of a lamp, so as to heat them strongly, they will char and burn away, leaving only a small quantity of ashes. That which disappears is usually termed the ORGANIC part of the plant, and consists of the four substances, Carbon, Nitrogen, Hydrogen, and Oxygen, which I have just described as the elements supplied to the plant by the atmosphere. The incombustible matter which remains behind, when examined, is found to contain all those substances which the plant had withdrawn from the soil, and is termed the INORGANIC part of the plant. Again, if you take a piece of animal matter, such as bone, and expose it to a strong heat, you will find that a part of it also will be consumed, its organic part, and that an incombustible matter will be left containing nearly the same substances as were contained in the inorganic parts of wheat. During the decay and putrefaction of both plants and animals, precisely the same thing occurs as we observe when we expose them to heat, their carbon, nitrogen, hydrogen, and oxygen, gradually escape into the atmosphere, from which they were originally derived, and there unite together once more to form the carbonic acid, the water, and the ammonia, which is destined, in process of time, to build up the bodies of another generation of man and animals, and to clothe the face of the earth with a new vegetation. The inorganic part of a plant weighs considerably less than the organic, as you will find upon repeating the simple experiment which I have described above, with a portion of any vegetable substance. Burn, for example, 100lbs. of potatoes, and you will not procure more than about four pounds of ash; yet this small portion of ash is as essential to the full growth of the potato as the 96 lbs. which you burn away.

The great object of all cultivation is to introduce into plants those substances which are adapted to the food of man. In their natural state they receive, from the air and the soil, merely food enough for their own support, the elements required to form the blood of man are contained in them in very small quantities. It must always be borne in mind by the farmer, that our cultivated crops are in a state as much unlike that intended by Nature as the stall-fed ox, which has been made to attain an enormous development of fat by excessive supplies of the most nutritious food, is unlike the cow which is obliged to seek its nourishment over an extensive range of scanty mountain pasture. Transplanted by man from their native soil, and collected, for his convenience, around his dwelling, there has been produced by art a forced and unnatural development of all their parts, but especially of their seeds, and to maintain this forced development the utmost care of the farmer is required; for should he trust his fields to nature, I need scarcely tell you, that his crops would again return to their natural state, or perhaps entirely disappear. It is well known that the produce of an acre of the wild potato in Chili, its native country, would scarcely suffice for the daily consumption of an Irish family, yet the wild plant and the cultivated are equally exposed to the influence of the atmosphere; the difference in their value as food must therefore depend entirely upon the amount of nourishment supplied by the soil. When the incombustible matter, which remains behind, after burning a piece of animal matter, such as bone, is examined by the aid of chemistry, we find that it consists chiefly of an acid containing phosphorus, called *Phosphoric Acid,* with some *Lime* and *Magnesia.* You may remember that I stated to you, that the composition of the ashes of animal matter is similar to that of the incombustible part of vegetables, and you will find, if you examine a table in which the composition of bone and of the grain of wheat, that part which is cultivated for food, is given, that the bones of animals contain from 67 to 68 per cent. of inorganic matters, consisting chiefly of compounds of phosphoric acid *(Phosphates),* while wheat contains so much as 96 per cent. of the same substances. It will at once occur to you, that upon the presence of the phosphates in our wheat its value as food chiefly depends. The successful practice of agriculture requires that the farmer, whose object it should be to produce the largest amount of food upon the smallest possible ground, should make himself acquainted with the mode of supplying his crops with those substances which are indispensable to their full development. If those substances do not exist in his fields in sufficient quantity, his wheat and his other crops may spring up, but they will not thrive—and even did they grow they would be useless as food; for, unless the plants which we consume contained phosphoric acid, magnesia, and lime, our system could no more form bone or muscle, than a carpenter could form a table if we kept from him the wood.*

For thousands of years men have been content to remain ignorant of the beautiful relations which, ever since the creation, have connected together animal and vegetable life. They composed learned treatises upon the geography of the moon, and the nature of its inhabitants, while they neglected to investigate the composition of the soil of this globe, and of the plants which ministered to their own existence.

The careful study of the food of plants, by Liebig, gave us the first correct notions respecting the true constitution of the soil, and of those curious processes by which the incombustible inorganic substances, which I have just described, enter into the circulation of our corn and other crops, which are cultivated as food, and led the way to the establishment of Agricultural Chemistry upon the immoveable foundation of observation and experiment. Before that, when any of those inorganic substances were discovered by the chemist to be contained in plants, it was imagined that they were there only by accident; but it has now been proved, beyond all question, that they are invariably present in our crops, contributing not only to their growth, but, by a wise and beautiful arrangement of the Creator, affording to animals those substances required for the formation of their bodies. Upon analyzing the dung, and other excrements, of animals, we find that these inorganic matters are again discharged from the body, again to be taken up by the vegetable tribes; and thus, ever on in an eternal round, they perform the part assigned to them in the economy of the Universe, in contributing to the support of organic life![*]

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* If the weight of the straw, and also of the grain, used in the experiment above described had been ascertained before burning them—and also the weight of ashes left behind—it would be found that the straw and the grain contained unlike quantities of inorganic matter; and a chemist would discover, besides, a considerable difference in their composition. In the straw ash he would find 70 per cent of a compound of silica and potash (*silicate of potash*), and only about 7 per cent. of phosphates; while in the grain, he would discover scarcely 1 per cent. of silica, and more than 96 per cent. of phosphates.

Amongst the most interesting and instructive researches which have lately been made, respecting the substances which plants withdraw from the soil, are those of two German chemists, Weigmann and Polstorff. These philosophers caused the seeds of different species of plants to vegetate in sand which had been heated to redness, and treated with acids, so as perfectly to remove all organic matters; and also in artificial mould, made by mixing together the substances which are contained in fertile soils. By careful analyses of samples of the seeds employed in these experiments, the exact quantities of the inorganic elements contained in them were ascertained. The soils prepared, as described, were carefully protected, by being enclosed in cases, and watered with pure water free from ammonia. In the pure sand it was found that the plants shot up, but soon decayed; while in the artificial soil they flourished vigorously, producing ripe fruits and perfect seeds. The plants obtained in both cases were analyzed, and the result was, that the plants grown in pure sand contained about twice the weight, and those grown in the artificial soil from four to five times the weight of inorganic substances in the seeds used. To ascertain how the increase in the weight of the inorganic elements of the plants grown in what was considered as pure sand had occurred, a portion of it was submitted to analysis, and was found to contain silica, potash, lime, oxide of iron, and other substances, resulting from the decomposition of some grains of felspar (one of the ingredients of granite) which were contained in it, and which had been rendered soluble by the action of the carbonic acid of the atmosphere.

Thus when you understand that plants extract from the soil the inorganic substances existing in it, you will easily comprehend how what is termed *exhaustion* of a field is produced; for, let us suppose, that in the soil of a field there are just 520lbs. of one of those substances, silica, for example, which is particularly required for the growth of your wheat, and that, by an examination of the whole amount of crops raised in the field, we find that it has taken up 260lbs. of that substance, it is evident that if we raise another crop of the same kind, in the following year, the field must have no silica for the plants in the third year, and the soil will then be exhausted for wheat. But different plants require different quantities of silica, and the other substances supplied by the soil for their support, so it happens that a soil which has become exhausted, and totally barren to one description of crop is, in the highest degree, nutritious to another. Thus, upon a field which would yield inorganic substances sufficient for the growth of one crop of wheat, we can raise three crops of oats, and in a field containing the quantity of silica, 260lbs., which I have mentioned as required for one crop of wheat, we would have more than sufficient of that one element for five harvests of peas. It is upon the knowledge of this fact that the *rotation of crops* is founded—the judicious application of which has been of so much service to agriculture. You are now, I think, prepared to agree with me, that the presence of the inorganic matters which remain after burning a plant is not accidental, but that they form an essential part of its food, absolutely necessary to its full development. Different plants, as you have heard also, require different *proportions* of those elements for their growth, and it will at once suggest itself to you, that it is only by obtaining an accurate knowledge of these proportions that we can, with any degree of certainty, decide upon the kind of soil best adapted to the production of any species of crop. It is only by the assistance of the chemist that we can hope to acquire this indispensable knowledge.

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[*] The inorganic substances which have hitherto been discovered in the ashes of land vegetables are, according to the recent researches of Drs. Will and Fresenius of Giessen, as follow:—Potash, soda, lime, magnesia, peroxide of iron, oxide of manganese, silicic acid or silica, phosphoric acid, sulphuric acid, carbonic acid, chlorine, fluorine.

THE ORIGIN AND COMPOSITION OF NATURAL SOILS.

Let us now direct our attention to the source from which the inorganic materials of plants are derived—*the Soil.* If you take a walk over your farm, and observe the rocks of clay slate which almost everywhere in this part of the country elevate themselves through the cultivated ground, you will find that in various parts the natural slate grey colour of the stone has changed to a yellow red, and that the rock in those places crumbles to pieces at the slightest touch. These changes in the character of the rock are produced by the slow, but certain influence of the atmosphere—the same resistless influence under which the proudest structures of man's skill must crumble into dust.[*] The progress of this process of *disintegration,* as it is commonly termed, may also be traced, with great distinctness, in those places among the Mourne mountains, where the surface of the granite is exposed. You will find masses of granite presenting every variety of form, from the flinty unaltered rock to the dull crumbling powder, which is easily washed away by the rain, and deposited on the fields.[†] It is by a similar process of disintegration that the naked coral reefs of the Pacific, and the lavas of Vesuvius become in a short time covered with verdure, and are rendered capable of producing the richest crops. It is by the crumbling down of the rocks of a country in this manner that soils are produced, and the mechanical operations of the farmer, who breaks up the surface of his field, by ploughing, pulverizing, and exposing it to the

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[*] In almost all rocks there is contained a compound of the metal iron with oxygen, termed by chemists *oxide of iron,* which has the property, when moisture is present, of attracting more oxygen from the air, and forming with it *peroxide of iron,* and as the addition of more oxygen adds to the bulk of the compound, its particles are removed to a greater distance from each other, which renders the rock so friable that it easily crumbles to pieces.—This is a beautiful provision of nature—the oxide of iron being injurious to plants, while the peroxide contributes to their growth.

[†] The granite of Mourne was examined by the late lamented Sir Charles Giesecke, Professor of Mineralogy to the Royal Dublin Society, and considered by him to bear a striking resemblance to the coarse-grained granite of Siberia; its three constituents, quartz, mica, and felspar, are more or less perfectly crystallized, and it contains besides some additional minerals resembling those found in the Siberian granite, viz.—Beryll, Topaz, Tourmaline, Cleavelandite. Mica contains a great variety of mineral ingredients, but decomposes very slowly. It is in the Felspar that we find those substances which supply our fluids with some of their most valuable inorganic materials. Liebig has shown that its decomposition is greatly facilitated by the application of lime to the soil. Felspar contains—

Silica, ...	65.5
Potash, ...	17.7
Alumina, ...	16.8
	100.0

influence of the air greatly facilitate this disintegration, and increase the amount of food, which it is capable of yielding, to his crops.—You may guess the qualities of the soil in any district, by the inspection of its rocks ; but it is only by means of a chemical examination that we learn its true composition, or ascertain the amount of substances useful for plants, which it may contain, and consequently the causes of its barrenness and fertility. Experience and careful observation have done much for the farmer, but their teachings are uncertain and insufficient—" they are like a vessel to which, in the form of science, the compass or the pilot is wanting. Experience is a treasure which cannot be inherited ; Science enables us to bequeath this treasure to our children, and it enables our children to increase their store."

In the observations which I have made, respecting the formation of natural soils, you must have remarked that I did not take into account a substance which is an almost invariable ingredient in the soils of this country, viz., the black powdery substance termed *Vegetable Mould.* To enable you clearly to understand the nature of this well-known ingredient of soils, I shall request you to make a simple experiment by means of a teaspoon and lamp, similar to that which was performed with the wheat and bone. Weigh a portion of soil from any of your fields, and expose it for some time to a strong heat, and you will find that its colour will change, and if you again weigh it you will see that, like the wheat and the bone, it has lost considerably in weight. However you will observe that the loss is not so great as when grain or animal matter is burned, a very small portion of the soil burns away, and a large quantity of incombustible, inorganic matter, remains behind. The composition of the matter which is consumed is precisely similar to that of the organic or combustible portion of animals and vegetables ; and this might, indeed, be expected, for its origin can be easily traced to the vegetables which have grown in the soil, and to the bodies of animals which have been interred in it, and which, by the process of decay, have been changed into Vegetable Mould. In some soils, such as those which the industrious use of the crowbar and pickaxe have for the first time, brought into cultivation among the bare stony hillocks of this neighbourhood, and in the valuable soils formed by the crumbling down of the rotten Basaltic rocks of Antrim,* there is very little if any of this substance, while in reclaimed bogs and in old gardens you will frequently find so much as 70 per cent. of it. Formerly, the most exaggerated notions of the importance of this portion of the soil were entertained, both by scientific and practical men ; and even yet, some persons have not been able to divest themselves of the idea that it forms an essential part of the food of plants. This is not the place to bring forward the powerful reasoning which has been urged against this opinion ; it will be sufficient to state to you that it is perfectly without foundation. It has been shown that this substance is insoluble in cold water, and scarcely, if at all, soluble in boiling water, and that it is totally absent in some of the most fertile and productive soils in the world.

Though Vegetable Mould cannot be taken up as food, there is another way in which—as has been beautifully shown by Liebig—it proves beneficial to the growing plant. Recal to your mind what I mentioned to you respecting the changes which plants and animals undergo during the progress of decay ; how their organic elements resume their original gaseous form, and unite together, so as to produce the compounds, carbonic acid, water, and ammonia, and as this evolution of gas and watery vapour goes on until all the organic part of the decaying body—whether of plant or animal—is consumed, it is but reasonable to suppose that plants growing in situations where this copious formation of ammonia and carbonic acid is taking place, will, from the artificial atmosphere so produced, receive a larger supply of nitrogen and carbon, and grow with greater luxuriance, than if de-

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* According to the analysis of Professor Kane, to whose valuable work on "The Industrial Resources of Ireland," every student of this subject must feel the greatest obligation, the basaltic or trap-rocks of Antrim contain in 100 parts—

Silica - -	51.17
Alumina - -	18.29
Lime - -	6.12
Magnesia - -	1.80
Oxide of Iron -	20.60
Water - -	2.03
	100.01

pending solely upon the air; and all experience proves such to be the fact.

In addition to the substances which serve for the food of plants, there is, in every field, a large portion of soil which contributes nothing to their nourishment; its presence, however, is indispensable to their mechanical support, and its nature must also agree with the habits of the crop which it is the object of the Farmer to raise; thus plants which extend their roots to a considerable depth in search of food cannot be expected to thrive in tenacious clay soils, which resist their progress, while others that, like wheat, penetrate but a short way into the earth, require a firm adhesive soil, to give a proper support to their tall stalks. Having now given you a brief, but, I trust, intelligible sketch of the food which our cultivated plants require for their support, and also of the store of nourishment which nature has provided for them in the air and in the soil, I shall make a few observations upon—

THE NATURE AND USE OF ARTIFICIAL SOILS OR MANURES.

This is a most interesting subject, and, I need scarcely remind you, of the greatest practical importance to every farmer. Its full consideration would, however, require more time than we can at present devote to it; and I shall merely select such portions of it as may best illustrate the advantages which you may derive from correct views regarding it. There is, in fact, no subject which more strikingly exhibits the benefits derived from the application of Chemistry to Agriculture, and no department concerning which such a diversity of opinion and so much ignorance prevail.

I have endeavoured to shew you how, by the continued cropping of a field, it becomes exhausted, simply because, year after year, the inorganic substances existing in the soil have been absorbed by the roots of the plants, and carried away from the land in the corn and the cattle which the farmer brings to market. Nature would, in time, by the decomposition of the flint or granite, or clay-slate or sand-stone, which exist in the soil, separate the inorganic matters contained in them, and thus produce a new supply for the nourishment of plants. There are some countries where the decomposition of the mineral ingredients of the soil goes on with so much rapidity, that, every one or two years, a sufficient quantity of Silicate of Potash is separated to supply a crop of wheat; but such is not the case in this country. It requires several years to enable the Felspar and the clay-slate of our fields to separate enough of that substance; and, besides, the process would be too tedious for the Irish farmer, whose necessities oblige him, year after year, without any intermission, to raise large crops. He cannot afford to wait, and he is accordingly obliged to seek the assistance of some artificial means, by which he can force the rocks in his fields to yield up their inorganic matter in a state capable of being taken up by his crops, or by which he can form *an artificial soil,* containing the materials required for the development of his plants. It is Agricultural Chemistry alone which can show the farmer what the plant has taken away from his fields, the substances required to prevent their exhaustion, and the true composition of artificial soils or manures.

In fifty years a new generation of farmers will arise, that will regard with astonishment the state of agriculture in this country at the present time. They will talk with the same kind of contempt of the smoking manure-heap of our farm-yards, as the traveller who now leaves Downpatrick in the morning, and sups in Dublin in the evening, speaks of the journeyings of his grandfather, who occupied a week on the way, and, previous to his departure, settled his affairs with as much anxious thought as we now bestow upon a voyage to China. They will smile at the folly of men who fit out navies to ransack the distant shores of South America, and the islands of the Pacific, for a substance, thousands of tons of which, by the defective arrangements of their cities and houses, are annually thrown away into the ocean. There is no subject upon which information is so much required by our farmers as upon the nature of manures. Everywhere the most absurd opinions and practices prevail, and everywhere we find the ground loaded with applications, without any regard to the materials which its condition actually requires.* It is time that such conduct should cease;

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* An instructive case, in illustration of the above, lately occurred in Wigtonshire—it is related by Professor Johnston. A farmer had succeeded to a lease of land that had been grain-cropped regularly for 15 years by his predecessor. The soil was, of course, in a very bad state, and he thereupon

for, is it not the same kind of absurdity which the quack commits, who attempts to cure a disease, of the nature of which he is totally ignorant, and applies his remedies at random, for the farmer to cover his fields with lime, or marl, or guano, without having the least idea either of the nature of the remedy which he applies, or of the wants of the soil? Hence, it naturally follows, that scarcely two farmers have formed the same opinion respecting the value of these applications. You will find one man praising them to the skies, while another laments the money he has, as he conceives, thrown away upon them. The only cure for all this is a proper chemical examination of both the soil and the manure. It may seem strange to the farmer who begins to reflect upon these things, how plants establish themselves along our ditches, and thrive for years with undiminished vigour, though totally neglected by man. It is only, however, where the soil is adapted to the growth of the weed, that it springs up spontaneously, and flourishes. There is nothing which, to a careless observer, appears so irregular and uncertain as the distribution of plants. But chance has nothing to do with the growth of even the meanest weed. The winds of autumn pass over our fields, carrying with them the seeds of a thousand different plants; but only those which find a resting-place containing the inorganic substances required for their development come to perfection. Hence, every soil has its peculiar kind of vegetation—its own weeds. The saltwort or the bent are never found growing along the shores of the inland lake, nor the white clover or the buttercup on the sands washed by the tide. Thus, the beautiful scarlet poppy springs up only where the soil is calcareous, or where lime has been applied; while, in a pure limestone soil, wheat perishes, and the quicken is never found as a weed. In the streams which flow through our marly valleys, the water-cress finds its proper food, while

proceeded to improve it. This he did by adding large quantities of farm-yard manure. But the soil was only exhausted of a certain substance—viz., phosphoric acid; and so, in adding farm-yard manure, he had been laying on large quantities of substances which were not required. The needless expense he was putting himself to may be inferred from this, that he perhaps laid on 50 tons of manure, costing him £12, 12s.; whereas, if he had applied bone-dust, which is the simplest way of putting on phosphoric acid, the same purpose would have been served, at less than one-fifth the expense.

the valleys themselves are covered with the broad leaves of the colts-foot. The reed and the horsetail require a different kind of food, and we find them thriving luxuriantly in the clay marsh, the waters of which are rich in silicate of potash.* How, you will ask, do the wild plants of the wayside and the moor grow, year after year, on the same spot, without exhausting the soil? Who cares for them? The reason is plain. They are not cut down and carried away every harvest like the crops of the farmer, but they bring their seeds to perfection, decay, and restore again to the soil the elements which they had removed from it; so that, after having treasured up the seed in its bosom during the winter, the soil is again able to supply it with the inorganic substances required for its growth, when the soft voice of the young spring awakes it to new life. Here nature gives us a lesson. IT SHOULD BE A GOLDEN RULE TO THE FARMER TO RESTORE TO THE FIELD THE ELEMENTS WITHDRAWN BY HIS CROPS, FOR IT IS ONLY IN PROPORTION AS HE IS SUCCESSFUL IN ACCOMPLISHING THIS RESULT THAT HE CAN MAINTAIN THE UNINTERRUPTED FERTILITY OF HIS FARM.

Among the inorganic substances which are furnished by the soil, there are some of more consequence than others. The substances containing phosphorus, termed phosphates,† for instance, have been discovered in the ashes of all plants yet examined; and their presence in the soil, as I have already mentioned to you, is absolutely essential to the formation of the seeds of our cultivated crops, and also to the production of the blood and bones of animals.

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* Some weeds are remarkable for the quantity of potash which they withdraw from the soil. An instructive illustration of this fact is given by Liebig:—The proprietor of a farm in the vicinity of Gottingen, in the kingdom of Hanover, planted his whole land with wormwood, the ashes of which are known to contain a large quantity of a combination of potash with carbonic acid (carbonate of potash); the consequence was, that the weeds withdrew all the potash from his fields, and rendered them incapable, for many years, of supporting grain. The wormwood, and other weeds which withdraw potash from the soil, abound along the ditches in the neighbourhood of Downpatrick. They should be carefully collected by the farmer, and added to his manure-heap; for every root of wormwood which his land nourishes robs his wheat of a portion of its necessary food, and consequently diminishes the produce of his farm. It requires no argument to prove, that two plants which withdraw the same food from the soil must mutually injure one another. A careful farmer would no more permit the growth of weeds in his fields, than he would a robber in his orchard.

† PHOSPHORUS is a very singular elementary substance, which is invariably contained in the fluids and bones of the higher animals. It has a light amber colour, and is usually so soft that it can be easily bent. When cut with a knife, its surface presents a waxy lustre. The greatest caution is re-

In this country, the supply of phosphates in the soil is being rapidly exhausted, and we are every year sending off enormous quantities of them in the cattle and the grain which we send out of the kingdom. Among the remedies for this exhaustion, bone dust and guano[*] are at

quired in handling it, for, when exposed to the air, it attracts oxygen from it, and frequently takes fire. By setting fire to a small bit of it, and covering it, whilst burning, with a tumbler, white fumes will be produced, which deposit themselves on the glass, and have a sour, acid taste. This sour substance is what is termed phosphoric acid. In 1lb. of bones, there is contained phosphoric acid sufficient for 28lbs. of wheat, or 250lbs. of potatoes.

[*] A few remarks upon this important manure may, at the present time, be interesting to the County Down farmer. It is, as is well known, the dung of sea-fowl, deposited, during many thousand years, upon the islands in the South Sea, off the coast of Peru, and also on the coast of Africa. The Chincha Islands, which afford the best American guano, are three in number, and each island, which is from five to six miles in circumference, is covered with this deposit, in horizontal strata, rising, in some places, to the height of 200 feet. It varies in colour from light to dark brown, and is entirely free from any mixture of earthy matter. Already, the immense demand for this substance has given rise to its extensive adulteration; and, besides, many cargoes which have really been imported, have lost considerably in value by decomposition. It is recommended by some persons to estimate the value of a sample by the strength of its ammoniacal or hartshorn odour; but this is an entirely mistaken direction, as sound Peruvian guano has no smell of ammonia, and we only perceive that odour *when it has begun to decompose and waste.* Guano rapidly absorbs moisture from the air and increases in weight. Of this the purchaser should be aware, or he will be paying for water; while genuine guano loses only about from 7 to 8 per cent. of its weight when exposed to the heat of boiling water. The sample should also never contain more than 2 per cent of sandy matter. I might have given directions for the chemical examination of guano; but, as this process is seldom conducted by the farmer, I consider that it will be more useful to give a few hints for its preservation and management. It contains ammonia, and should, therefore, as that substance evaporates by exposure, be preserved in close casks. With African guano, which contains that substance in an uncombined state, this precaution is especially required. Rub two teaspoonsful of it in a cup, with about the size of a nut of fresh-slaked lime, and you will have evidence, by the pungent smell produced, of the large quantity of ammonia which it contains, and also of the impropriety of mixing it with quicklime or ashes.

present largely employed. The most extraordinary demand for the last-named fertilizer may be regarded as a proof of the necessity for some application of the kind to our worn-out fields. The substance which we term guano, and which, at the present time, excites so much interest, though described by the celebrated Davy in his "Lectures on Agricultural Chemistry," was, six years ago, scarcely known, even by name, in this country. About five years ago I received a small bit of it as a curiosity, taken from a heap lying upon one of the quays of Liverpool. Since that time, more than 40,000 tons of it have been imported into the United Kingdom, and its trade has become an important branch of industry. Already the most beneficial results have attended its employment as manure, and our farmers are eagerly availing themselves of its assistance. There are various opinions put forward as to which of the numerous substances contained in guano it is indebted for its value. You have already been informed that, among the principles contained in plants, and furnished by them to animals, the phosphates are by far the most important. In Guano, we have always a large proportion of these substances, and Liebig contends that it is upon their presence that its importance as a fertilizer depends. But there is a manure which, when properly managed, is of greater importance to the Irish farmer than any derived from a foreign and uncertain source—that is, the offal of the farm-yard.—Chemical examination teaches us, that in this manure, we have all the elements necessary to vegetable life.† Nature always producing

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Dip a feather in vinegar, or spirits of salts, and hold it over the cup, and copious white fumes will be formed. Stir about a teaspoonful of powdered gypsum, or a few drops of vitriol mixed with water into the cup, and again bring the feather over it, and you will find that no white fumes will now be formed, and that the pungent smell can no longer be perceived. The gypsum and the vitriol have *fixed* the ammonia; and either of these substances, it is found, may advantageously be mixed with it. As it is injurious to place it, in its pure state, in contact with seeds, or tender plants, it is recommended to mix it with sand, powdered charcoal, or soot. The presence of rain, or artificial watering, is necessary for its operation. The Peruvians irrigate immediately after its application.

† The celebrated French chemist, Boussingault, has instituted the most extensive experiments upon this subject, at his model farm. By comparing the composition of the farm-yard manure which he applied to his fields, as given in the following analysis, with the constituents found in the ashes of plants, (p. 13,) you will perceive that it contains all the inorganic substances

offal enough to preserve her power of reproduction unimpaired, when her supplies are properly husbanded by man. I have already explained to you that in the wheat and other grains, and in the flesh of the animals which we consume as food, we take into our system to form bone and muscle, a large amount of compounds of phosphoric acid, which must, at one time, have formed a portion of the soil of our fields. By those wonderful changes which are incessantly going on in the human body, those mineral compounds are again separated from it; and, in the urine and excrements of man and animals, we find all the inorganic matter which was contained in their food. Here we are presented at once with all the substances required to maintain the fertility of our fields. For centuries the Chinese, whom we regard as a barbarian nation, have considered urine and excrements as their most valuable manure, and, by using them, produce the most abundant harvests; while we, who regard ourselves as most enlightened people, are scarcely yet alive to their importance. By mixing the waste straw of the farm-yard with the excretions of animals, we form a mixture containing all the materials which our crops can require for their development. In the decomposed stalks of plants we

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required for the development of your crops. This manure usually contains 79.3 per cent. of water, 20.7 of dry matter, and its ashes in 100 parts are composed of—

Carbonic acid	2.0
Phosphoric acid	3.0
Sulphuric acid	1.9
Chlorine	.6
Silica, sand, and clay	66.4
Lime	8.6
Magnesia	3.6
Oxide of iron, and alumina	6.1
Potash and soda	7.8

In addition to these substances, good manure always contains a large amount of ammonia, which could not be shown in the analysis, being, of course, driven off by the heat used in preparing the ashes. To prevent the loss of the ammonia, which is constantly given off from stables and manure-heaps, the farmer should provide himself with 1lb. of vitriol, which costs about 3d., which he should mix with 30lbs. of water, and sprinkle it on sawdust spread in different parts of the stable, and also over his manure-heap. Gypsum, which is also a cheap substance, and is itself valuable as a manure, can, with advantage be used for the same purpose. It should be sprinkled frequently over the tank containing the offal. Ammonia contains 82 per cent. of nitrogen.

have silica, in a state capable of being taken up by the grass tribes, while the excrements of man contain a rich supply of phosphates; and urine furnishes, by its decomposition, abundance of ammonia, and other valuable principles. A mixture so prepared will, by the economical farmer, be considered as superior to guano, for that substance does not contain all the elements which plants require for their food; and in Norfolk, where it has been largely employed, it was found that, from a deficiency of the silicates in the artificial soil produced by it, the stalk of the wheat crop was unable to support the weight of the head. If you neglect the manure lying at your own doors, you are neglecting the true remedy provided by nature herself for restoring the fertility of the soil; and, when you are informed that, with every pound of ammonia which escapes from a manure-heap, 60lbs. of corn, and with every pound of urine which we allow to waste, 1lb. of wheat might be produced, you will, I trust, be convinced that it is your interest to adopt some means for their preservation.

It is important that the farmer should have correct opinions on these subjects. The day for being content with guess-work farming has gone by. The agriculturists of England and Scotland have led the way, and the success which has attended their efforts should encourage you to avail yourselves of every aid which science can afford. There is one great obstacle to the advancement of agriculture in this kingdom, which I cannot pass over without notice—that is, the want of agricultural education among our farmers. Practical skill in the mechanical management of the farm is truly of great importance; but too many are satisfied with themselves, and consider that everything necessary to insure an abundant harvest has been done, when they can make their fields as smooth as the floors of their parlours.

But such farming is not sufficient for the wants of the country at the present time. How does it come to pass that Ireland, though surpassing England in the fertility of her soil, and, as has been proved, in the physical strength of her labourers, is yet so little advanced in the art of culture? The simple answer is, that though our farmers are superior to the English in general education, they are generally deficient in that special professional knowledge which is required for the successful practice of agriculture. A great effort for the diffusion of this important knowledge is, at the present time, being made, both in this country and in England. To meet the urgent demand for some means by which the valuable assistance of chemistry might be rendered more available to the agriculturist, a College of Chemistry is now being established in London. In Ireland, we already possess several valuable institutions and associations, by the efforts of which, in the same direction, much good might be done. We have the parent of them all—the Royal Dublin Society—which has, for upwards of a century, been labouring to promote industrial knowledge. We have the Agricultural Schools of the Board of Education. We have the Royal Agricultural Society of Ireland, which has already done so much towards advancing husbandry in this country; and we have, in our own part of Ireland, the Flax Society, the publications and meetings of which have been so useful in disseminating industrial information among our farmers. Agricultural associations are, everywhere, in operation over the kingdom; and they have, by their labours, accomplished wonderful things. The old, massy embankments, and deep trenches, which occasioned so much waste, and made the fields in this country resemble fortified grounds, are rapidly disappearing. Straight mearings are being substituted for the zig-zag divisions of our forefathers; and, everywhere, the soil is better cleaned, and earlier ploughed. Subsoiling and furrow-draining are also being extensively employed, and with the best effects.

But more is yet required from these societies than merely encouraging mechanical improvements. In this country, we are deficient in one of the chief elements of agricultural progress—viz., a knowledge of the composition of our soils; and, until this great want is supplied by chemical investigation—until we possess exact analyses of the soil of every parish in the kingdom—we must remain ignorant of the most essential information which is required to render all efforts for their improvement successful—a knowledge of the causes of their barrenness or fertility. It is to chemistry that the Irish farmer must look forward for any great improvement in the produce of his fields. There is no science, the progress of which has exercised so powerful an influence upon civilization, or which promises to do so much to promote the prosperity and happiness of those who live by the soil. I trust I have now succeeded in convincing you, that it is your interest, and that it should be the sincere desire of every friend of Ireland, that the assistance which this science offers should be at once obtained.

THE END.

ERRATA.

The reader is requested to correct the following Errata :—

Page 10, line 11 from bottom, *for* "is destined" *read* "are destined."
—— 11, — 6 ditto, *for* "while wheat" *read* "while the incombustible part of wheat."
—— 16, — 8 from top, *for* "has done" *read* "have done."
—— " — 3 from bottom, *for* "has for the first" *read* "have for the first."

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